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Department

A Bibliography of Electrophoretic Studies Relating to Genetic Protein Variation in the Atlantic Salmon *Salmo salar* L.

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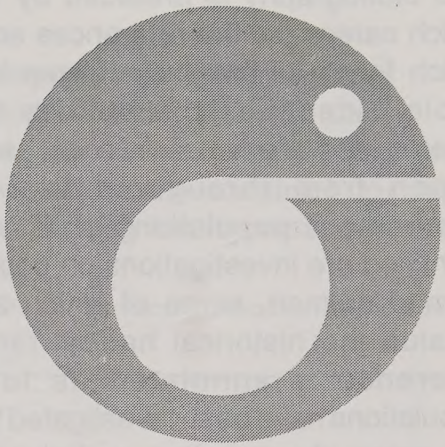

I F Wilson and E Verspoor,
SOAEFD Marine Laboratory, Aberdeen

Introduction

A substantial literature now exists on electrophoretically detectable genetic protein variation in the Atlantic salmon *Salmo salar L.* However, the published work is widely distributed in the literature and a substantial amount of documentation is in the form of unpublished reports and theses. This provides an obstacle to researchers by making awareness of, and access to, the literature difficult, thus preventing them from deriving the full benefits of the work that has already been done. The widespread availability of a comprehensive bibliography of existing work would be valuable in this regard. Existing reviews of the field, such as Wilkins (1972a,b), Cross and Ward (1980) and Ståhl (1987), are either dated or were not aimed at being comprehensive in their coverage of the literature.

It is the need for an up-to-date, comprehensive bibliography which has led to the present compilation, and it is hoped that the one presented here will serve as a useful reference and aid to reviewing the subject. A review is something which may be timely given the current shift in focus of genetic studies in the species to direct analysis of DNA sequence variation. This makes the present a good time at which to pause and reflect on what has been done on the subject and use the insight thus gained to focus research more effectively in the future.

The bibliography is restricted to studies of electrophoretic protein variation which can reasonably be demonstrated to be attributable to Mendelian alleles at regulatory or structural loci controlling the production of proteins. It does not incorporate studies where, as in many papers reviewed in Wilkins (1972a,b), the basis of the variation may be ontogenetic or physiological. Otherwise, a comprehensive coverage is attempted, which should encompass the vast majority of documented work in the field. Identification of gaps in its coverage, studies still in progress, and data in filing cabinets remaining to be written up, mean that the bibliography will likely need to be updated at some time. This will be done if sufficient numbers of further references do come to light and will be published as an addendum. In this regard, it would be useful to have omissions and new work brought to our attention to facilitate preparation of an update.

The bibliography will be of little use unless the literature to which it refers can be accessed. Where primary publications are involved, this does not present a problem. However, it may often do so for unpublished documents. If documents prove unobtainable through inter-library loans, then in most cases they should be obtainable from the original authors. Failing this they can contact Eric Verspoor, who has copies of most documents, at the Marine Laboratory.

The bibliography is prefaced by five tables which categorise the references according to which facets of the subject area they cover. Table I identifies the studies that have investigated allozymes in each geographical region from throughout the range of anadromous populations of *S. salar.* Also identified are investigations on populations of farmed salmon, some of which are reared outside the historical natural range. Each reference is annotated as to whether populations have been investigated from within the same river system or between rivers, regions and continents, or any or all combinations of these. Review papers are italicised. Table II summarises the same information for non-anadromous populations. In Table III references are listed that report information on enzyme systems that have been found to be polymorphic in at least one population of *S. salar*, while the same is done in Table IV for enzymes that have so far been found to be monomorphic. Table V categorises references that have investigated genetic protein variation in relation to various aspects of salmon biology, such as population differentiation, mixed-stock analysis, hybridisation, demographic variation and adaptive significance.

Development of the bibliography is associated with the International Workshop on Genetic Protein Variation in Atlantic Salmon held in Aberdeen, Scotland 14-16 December 1988. The work of the participants in helping to assemble the known references at the time is gratefully acknowledged as is their patience in waiting for the translation of the bibliography from an idea into reality. We would especially like to acknowledge the contribution made by Sandra Johnston and the library staff at the Marine Laboratory in compiling references and by Tom Cross in encouraging and supporting the project. The preparation of the document and the Workshop were generously supported by funding from the Atlantic Salmon Trust in addition to that made available by the Scottish Office.

Table I

References with information on allozymes in wild native anadromous populations of S. salar from countries and regions around the Atlantic, and in various hatchery stocks. For each reference a letter code designates whether comparisons are made between populations within river systems (w), among river systems (b), among regions (r) and between continents (c). Review papers not containing original data or using data from other sources are italicised, while papers incorporating data reported elsewhere are italicised and underlined.

Country	Reference
Canada	15[brc], 135[c], 144[c], 242[rc]
Newfoundland/ Labrador	17[brc], 18[wbr], *19[w]*, 20[brc], 21[brc], *22[brc]*, *42[brc]*, *61[brc]*, *67*, 72, *82[brc]*, *85[brc]*, *97[rc]*, 109[bc], 144[rc], 117, 126[br], 127[br], 128[br], 129[br], 130[br], *132[wbr]*, 137, 150, 154[br], 163[wr], 169[wbr], *173[wbrc]*, *174[wbrc]*, *175[wbrc]*, *199[wbrc]*, *202[wbrc]*, *204[wbrc]*, 224[rc], *223[br]*, 226, *227[w]*, 228[brc], *229[wrc]*, 230[wbrc], 231[wbrc], *235[wbrc]*, *243[brc]*, *245[wbrc]*
Maritime	*5[brc]*, 6[wb], 7, 17[brc], 18[wbr], 20[brc], 21[brc], *22[brc]*, 25[wb], *45[wbrc]*, *54[wb]*, *61[brc]*, *80*, *82[wbrc]*, *85[wbrc]*, 103, 104[wb], *107[brc]*, 112, 114[rc], 126[wbr], 127[wbr], 128[wbr], 129[wbr], 130[wbr], *132[wbr]*, *154[br]*, 156[c], 163[wbr], 169[wbr], *173[wbrc]*, *174[wbrc]*, *175[wbrc]*, *194[wrc]*, 196, *199[wbrc]*, *202[wbrc]*, *204[wbrc]*, 224[brc], 222[wb], *223[br]*, 225[wb], *228[brc]*, *229[rc]*, *230[brc]*, *231[rc]*, *235[wbrc]*, 236[c], *243[wbrc]*, *245[wbrc]*, 249
Quebec	17[brc], 18[wbr], *82[brc]*, *85[brc]*, *107[brc]*, 126[br], 127[br], 128[br], 129[br], 130[br], 136[c], 138[rc], 139[brc], 168[wb], *173[wbrc]*, *174[wbrc]*, *175[wbrc]*, *199[wbrc]*, *202[wbrc]*, *204[wbrc]*, *223[br]*, 228[brc], 230[brc], *235[wbrc]*, *243[rc]*
USA	*5[brc]*, 17[brc], *97[rc]*, 107[wbrc], 126[br], 127[br], 128[br], 129[br], 130[bwr], 144[c], 169[wbr], *204[wbrc]*, *223[br]*, *243[brc]*
North Atlantic	
Greenland	15[brc], *59[c]*, 105[c], 140[c], 142[c], 143[c], 144[c], 153[c], 155[c], *157*, 160[c], 161[c], 166[c], 167[c], *173[c]*, *174[c]*, *175[c]*, *202[rc]*, *203[c]*, *204[brc]*, *235[rc]*, 241, 242[rc], *243[c]*, *245[c]*
Faroes	21[r], 22[r], 23[r], 27[r]
Iceland	*12[br]*, 15, 17[brc], *21[rc]*, *22[rc]*, 40[wb], *45[brc]*, *82[brc]*, 114[rc], 194[brc], *199[brc]*, *202[wbrc]*, *204[brc]*, *228[brc]*, 230[rc], *235[wbrc]*
British Isles	
Ireland	*3[rc]*, *12[br]*, 15[brc], 16[br], 17[brc], 20[brc], 21[wbrc], *22[brc]*, 23[wbr], 26[b], 27[wbrc], 28[wb], 29[b], *30[b]*, 31, 32, 33, 34, 35, 36[w], 37[w], 38[wb], *42[brc]*, 43, *45[wbrc]*, *50[br]*, 51, 52, 55[w], *61[brc]*, *80*, *82[wbrc]*, *83[wbr]*, *85[wbrc]*, 91, *97[c]*, *107[brc]*, 111[wbc], 113[wb], 114[wbrc], 115[wb], 116[wb], *118[br]*, 119, *122[r]*, *123[r]*, 144[c], 156[brc], 159, 160[c], *180[r]*, *194[rc]*, *198[r]*, *199[wbrc]*, *202[wbrc]*, *203[br]*, *204[wbrc]*, 217, *218[r]*, *224[rc]*, *228[brc]*, *230[rc]*, *235[wbrc]*, *237[r]*, 242[rc], *243[brc]*, *245[brc]*, 247[r], 248[r]
Scotland	15[brc], 16[br], 17[brc], *22[brc]*, 23[wbr], *45[wbrc]*, *50[br]*, 53[wb], 82[wbrc], *83[wbr]*, 84, *85[wbrc]*, 86[w], 87, 88, 89[wb], 90, 109[bc], *111[r]*, *118[br]*, *121[r]*, *122[r]*, *123[r]*, 144[c], 156[rc], 165, 198[r], *199[brc]*, *202[wbrc]*, *203[br]*, *204[wbrc]*, *224[rc]*, *228[brc]*, *229[rc]*, 230[rc], *231[rc]*, 232, *235[wbrc]*, 241, 242[rc], *243[brc]*, 247[r], 248[r], 251, *252[br]*, *253[br]*, 254
England and Wales	14[b], 15[brc], 16[br], 69, 70, 71[w], *83[wbr]*, *97[c]*, *118[br]*, 147[wb], 148[wb], 149[wb], 156[brc], *199[brc]*, 200[wb], 201[wb], *202[wbrc]*, *203[br]*, *204[wbrc]*, 230[rc], *235[wbrc]*, 242[rc], *243[brc]*

Country	Reference
Southern Europe	
France	*12*[br], 17[brc], *50*[br], 61[brc], *82*[brc], *85*[brc], *199*[wbrc], *202*[wbrc], *204*[wbrc], *228*[brc], *229*[brc], 230[rc], *235*[wbrc], 236[c]
Spain	*8*[b], 9[br], 10[br], *11*, *12*[br], 13[b], 56, 57[wb], *67*, *82*[brc], *85*[brc], 120[wb], 121[wbr], 122[wbr], 123[wr], *164*[r], *176*[wbr], 177[wb], 178, *179*[wb], *199*[wbrc], *202*[wbrc], *204*[wbrc], 219[wbr], *220*[b], *221*[wbr], 230[rc], 233[wbr], *235*[wbrc], 247[r], 248[r]
Scandinavia	
Sweden	*3*[rc], *5*[brc], *12*[br], 17[brc], *21*[brc], *22*[brc], 23[wbr], 41, *42*[brc], *45*[wbrc], *50*[br], *61*[brc], 73[wbr], 74[w], *75*[wb], 77, 78, 79[wb], *80*, *82*[wbrc], *85*[wbrc], 98[br], 99[br], 100[r], *102*[r], *107*[brc], 135[rc], 136[rc], 138[rc], 139[brc], 144[c], 170[wb], *171*[wbr], 172[wb], 192[wb], 193[wbr], *194*[wbrc], *199*[wbrc], *202*[wbrc], *204*[wbrc], *218*[r], *224*[rc], *228*[brc], *230*[brc], *235*[wbrc], *237*[r], 242[rc], *245*[wbrc]
Norway	*5*[b], *12*[br], 20[brc], 21[brc], *22*[brc], 23[wbr], *45*[wbrc], *61*[brc], 63, 64[w], *66*[b], *67*, *82*[wbrc], *85*[wbrc], 98[br], 99[br], *107*[brc], *122*[r], *124*[b], 125, 131, 183[b], *194*[wbrc], 195[wb], *199*[wbrc], *202*[wbrc], *204*[wbrc], *224*[rc], *228*[brc], *230*[brc], *235*[wbrc], 238[w], *245*[rc], *252*[br], *253*[br]
Finland	*12*[br], 44[wb], *45*[wbrc], 46, 47[wb], *50*[br], *61*[brc], *82*[brc], *85*[brc], 98[wbr], 99[wbr], 100[wbr], *101*[br], *102*[wbr], *199*[brc], *202*[wbrc], *204*[wbrc], *235*[wbrc], 239
Russia & Baltic States*	*49*
Baltic	*2*[b], *4*[wbr], *5*[brc], *82*[brc], *85*[brc], 92[wbr], 100[wbr], *102*[wbr], 180[wbr], 181, 185[w], *186*[w], *188*[wbr], 189[wb], *199*[rc], *204*[wbrc]
Arctic	*2*[b], *12*[br], *45*[wbrc], *82*[brc], 92[wbr], 93[wbr], 94[wbr], 98[br], 99[br], 180[wbr], 181, 187, *188*[wbr], *204*[wbrc], *205*[wb]
Hatchery Stocks	
Europe	*3*[r], *5*[brc], 9[br], 10, *11*, 17[brc], *24*, 29[b], 30[b], 36[w], 37[w], 38[wb], 40[wb], *50*, 55[w], 57[wb], 58, 60, 61[brc], 65[wb], *66*[b], 69, 76, 92[wbr], 93[wbr], 94[wbr], 95, 96[b], 98[wbr], 99[wbr], *107*[brc], *110*, 111[b], 113[wb], 115[wb], 116[b], 119, 120[wb], *124*[b], 134, 138[rc], 146[b], 147[wb], 149[wb], *164*[r], 172[b], 180[wbr], 181, *182*, 183, 184, 189[wb], 193[br], *194*[wbrc], 195[wb], 198[br], 201[wb], *202*[wbrc], *204*[wbrc], 206, 207, *208*, 209, *210*, 212, 213, 214, 216, 217, 218[r], 219[br], 221[r], *230*[rc], *233*[r], *235*[wbrc], 238[w], 239, *245*, 246, 247[r], 248[r], 252[br], 253[wbr], 254
North America	1, *3*[rc], *5*[brc], 6, 17[brc], 18[wbr], *24*, 25[wb], *54*[wb], 80, 81, 105[c], 106[b], *107*[brc], 108[wb], 161[c], *173*[wb], *174*[wb], *175*[wb], *194*[wbrc], *204*[wbrc], 222[wb], 225[wb], 236, 240[b], 248, 249, 250
Southern Hemisphere	240[b]

*Independent Baltic States of Estonia, Latvia and Lithuania

Table II

References to genetic protein variation in non-anadromous populations of *S. salar*

Country	Reference
Canada	17^{brc}, 18^{br}, *19*^{w}, *42*^{brc}, 150, 154^{b}, 163^{wbr}, 168^{wb}, *204*^{brc}, 224^{brc}, 226, *227*^{w}, *229*^{wrc}, 230^{brc}, 231^{wbrc}
USA	191, *204*^{brc}
Sweden	*4*, *42*^{brc}, 65^{wb}, 144^{c}, *194*^{wbrc}, *204*^{wbrc}
Norway	139^{brc}, 144^{c}, *194*^{wbrc}, *204*^{wbrc}, 238^{w}
Finland	136^{rc}, 138^{rc}, 144^{c}, 193^{r}, *204*^{rc}, 237^{wr}, 239
Hatchery stocks:	
Europe	93^{wbr}, 94^{wbr}, 98^{wbr}, 99^{wbr}, *171*^{r}, 180^{wbr}, 181, *194*^{rc}, *204*^{wbrc}, *218*^{r}
North America	17^{brc}, 18^{br}, 197^{wb}

Table III

References to specific enzymes and proteins in *S. salar* for which electrophoretically - detected genetic variants have been identified.

Enzyme or protein	EC number	Abbreviation	References
Aspartate aminotransferase (glutamic-oxaloacetic transaminase)	2.6.1.1	AAT (GOT)	1, 6, 9, 10, *11*, *12*, 13, 15, 20, 21, *22*, 23, 25, 26, 27, 28, 29, 30, 32, 34, 35, 36, 37, 38, 39, 40, *42*, 44, *45*, 46, 47, 53, 55, 61, *62*, 64, 65, 69, 71, 73, 74, *75*, 76, 79, 80, 82, *83, 85*, 87 89, 92, 93, 94, 95, 98, 99, 100, *102*, 106, 107, 108, 111, 112, 113, 114, 115, 116, 119, 120, 121, 122, 123, *124*, 146, 147, 148, 149, 150, 160, 166, 167, 169, 170, *171*, 172, *176*, 177, *179*, 184, 191, 192, 193, *194*, 195, 196, 197, 198, *199*, 200, 201, *203, 204, 205*, 217, 218, 219, *220*, 221, 222, 224, 225, 228, *229*, 230, 231, 232, 233, 237, 238, 239, 240, *245*, 247, 252, 253
Adenosine deaminase	3.5.4.4	ADA	32, *42*, 80, 82, *83*, 89, 107, 112, 113, 196, *204*, 217, 240, 247
Alcohol dehydrogenase	1.1.1.1	ADH	1, 6, 9, 10, *11*, 15, 32, 40, *42, 45*, 46, 55, 60, 61, *62*, 64, 65, 74, 76, 80, 82, *83*, 89, 95, 107, 111, 112, 113, 114, 116, 120, 122, 123, 150, 169, *171*, 172, *176*, 177, 191, 192, 193, *194*, 195, 196, 197, *199*, *203, 204*, 217, 218, 219, 237, 238, 239, 247
Creatine kinase	2.7.3.2	CK	1, 6, 9, 10, *11*, 15, 17, 32, 34, 35, 38, 40, *42*, 44, *45*, 46, 47, 61, *62*, 64, 80, 82, *83*, 89, 95, 98, 106, 107, 108, 109, 111, 112, 113, 114, 116, 120, 121, 122, 123, 168, *171*, 172, *176*, 177, 181, 184, *188*, 191, 192, 193, *194*, 195, 196, 197, *199*, *203, 204*, 217, 218, 219, 222, 225, 230, 231, 233, 237, 238, 239, 247, 250, 251
Diaphorase (dihydrolipoamide dehydrogenase, lipoamide reductase)	1.8.1.4**	DIA	9, 10, *11*, 34, 35, 38, 40, *42*, *45*, 46, *62*, 64, 80, 82, 89, 107, 112, 113, 114, 169, *171*, 172, *176*, 177, 184, 192, 193, *194*, 195, 196, 197, *199*, *204*, 217, 218, 219, 237, 247, 249
Esterases	3.1.1.-	EST	6, 7, 14, 15, 32, 34, 35, 41, *42*, 44, 46, 47, 60, 61, 77, 80, *83*, 96, 98, 107, 113, 114, *132*, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 147, 148, 149, 158, 169, 172, 181, 187, *188*, 190, *203, 204*, 238, 242, *243*, 246, 247
Esterase-D	3.1.-.-	EST-D (ESD)	32, 41, 76, 77, 92, 93, 94, 113, 180, 181, *204, 205*, 217, 246
Fructose-bisphosphate aldolase (aldolase)	4.1.2.13	FBALD (ALDO)	6, 15, *42*, 98, 113, 172, 191, *203, 204*, 217, 247
Glutamate dehydrogenase	1.4.1.-	GLUDH (GDH)	6, 15, 40, *42, 45*, *62*, 64, 98, 107, 113, *171*, 172, 192, 193, *194,* 195, 196, 197, *199, 203*, *204*, 217

**formerly 1.6.2.2, which is now cytochrome b_5 reductase

Enzyme or protein	EC number	Abbreviation	References
Glycerol-3-phosphate dehydrogenase	1.1.1.8	G3PDH (GPD)	1, 6, 14, 32, 34, 35, 37, 38, 40, *42*, 44, *45*, 46, 47, 61, *62*, 64, 76, 80, 82, *83*, 89, 95, 106, 107, 109, 112, 113, 114, 119, 120, 121, 122, 123, 138, 150, 169, 170, *171*, 172, 181, 184, *188*, 191, 192, 193, *194*, 195, 196, 197, *199*, *204*, 217, 237, 238, 239, 240, *243, 245*, 247
Glucose-6-phosphate isomerase (phosphohexose isomerase, phosphoglucose isomerase)	5.3.1.9	GPI (PGI)	1, 6, 7, 9, 10, *11*, 15, 32, 34, 35, 36, 37, 38, 39, 40, 41, *42*, 44, *45*, 46, 47, 52, 53, 55, 56, 60, 61, *62*, 63, 64, 65, 70, 71, 74, 76, 77, 79, 80, 81, 82, *83*, 84, 89, 95, 98, 99, 106, 107, 108, 111, 112, 113, 114, 116, 117, 119, 120, 121, 122, 123, 125, *132*, 147, 148, 149, 150, 169, *171*, 172, *176*, 177, 184, 191, 192, 193, *194*, 195, 196, 197, *199, 203, 204*, 217, 218, 219, 222, 225, 226, 230, 231, 233, 237, 238, 239, 240, *243*, 246, 247, 251, 254
L-Iditol dehydrogenase (sorbitol dehydrogenase)	1.1.1.14	IDDH (SDH,SORD)	1, 6, 9, 10, *11*, *12*, 13, 20, 21, *22*, 23, 25, 26, 27, 29, 30, 32, 36, 37, 38, 39, 40, *42*, 44, *45*, 46, 47, 53, 55, 61, *62*, 64, 65, 69, 73, 74, 75, 76, 79, 80, 82, *83, 85*, 87, 89, 92, 93, 94, 95, 98, 99, 100, *102*, 106, 107, 108, 109, 111, 112, 113, 114, 115, 116, 119, 120, 122, 123, *124*, 146, 147, 148, 149, 166, 167, 169, 170, *171*, 172, *176*, 177, 178, *179*, 184, 192, 193, *194*, 195, 196, 197, *199*, 200, *204, 205*, 217, 218, 219, *220*, 221, 222, 224, 225, 228, *229*, 230, 231, 232, 237, 238, 239, 240, *245*, 247, 249, 250, 251, 252, 253
Isocitrate dehydrogenase	1.1.1.42	IDHP (IDH)	1, 2, 6, 9, 10, *11*, *12*, 13, 17, 20, 21, *22*, 23, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 39, 40, *42*, 44, 46, 47, 53, 55, 61, *62*, 64, 65, 71, 73, 74, 75, 78, 79, 80, 82, *83*, *85*, 87, 89, 92, 93, 94, 95, 98, 99, 100, *102*, 106, 107, 108, 109, 111, 112, 113, 114, 115, 116, 119, 120, 121, 122, 123, *132*, 146, 147, 148, 149, 150, 151, 159, 168, 169, 170, *171*, 172, *176*, 177, 178, *179*, 180, 184, 185, *186*, 191, 192, 193, *194*, 195, 196, 197, 198, *199*, 200, *203, 204*, *205*, 217, 218, 219, *220*, 221, 22, 225, *229*, 230, 231, 232, 233, 237, 239, 240, 247, 249, 250, 251, 252, 253
L-Lactate dehydrogenase	1.1.1.27	LDH	1, 6, 9, 10, *11*, 14, 15, 17, 32, 34, 35, 38, 40, *42*, 43, 44, *45*, 46, 47, *49*, 52, 61, *62*, 64, 71, 74, 76, 79, 80, 81, 82, *83*, 89, 91, 95, *97*, 98, 99, 106, 107, 108, 109, 111, 112, 113, 114, 116, 120, 121, 122, 123, 138, 147, 148, 149, 150, 158, 168, *171*, 172, *176*, 177, 191, 192, 193, *194*, 195, 196, 197, 198, *199, 203, 204*, 217, 218, 219, 222, 225, 230, 231, 232, 233, 237, 238, 239, 240, 241, 242, *243*, 247, 249, 250
Lactoylglutathione lyase (glyoxalase I)	4.4.1.5	LGL (GLO1)	32, *42*, 113, *204*, 217, 247
Malate dhydrogenase	1.1.1.37	MDH	1, 6, 9, 10, *11*, *12*, 13, 14, 15, 17, 18, 20, 21, *22*, 23, 25, 26, 27, 29, 30, 32, 34, 35, 36, 37, 39, 40, *42*, 44, *45*, 46, 47, 53, 55, 60, 61, *62*, 64, 65, 71, 72, 73, 74, *75*, 76, 79, 80, 82, *83*, 89, 95, 98, 99, 104, 106, 107, 108, 109, 111, 112, 113, 114, 115, 116, *118*, 119, 120, 121, 122, 123, *132*, 146, 147, 148, 149, 150, 166, 167, 168, 169, 170, *171*, 172, *176*, 177, 178, *179*, 180, 184, 185, 191, 192, 193, *194*, 195, 196, 197, 198, *199, 203, 204*, 217, 218, 219, *220*, 221, 222, 224, 225, 228, *229*, 230, 231, 232, 233, 236, 237, 238, 239, 240, 242, *243, 245*, 247, 249, 250, 252, 253
Malic enzyme (NAD*) (malate dehydrogenase	1.1.1.38 1.1.1.39	ME	82, *83*, 89, 236, 247

Enzyme or protein	EC number	Abbreviation	References
Malic enzyme ($NADP^+$) (malate dehydrogenase)	1.1.1.40	MEP	*2*, *8*, 13, 17, 20, 21, *22*, 23, 25, 26, 27, 29, 30, 32, 33, 36, 37, 38, 39, 40, *42*, 44, *45*, 46, 47, 53, 55, 57, 58, 61, *62*, 64, 65, 69, 71, 73, 74, *75*, 76, 79, 80, 82, *83*, *85*, 86, 87, 88, 89, 90, 92, 93, 94, *97*, 98, 99, 106, 107, 108, 109, 111, 112, 113, 114, 115, 116, 119, 120, 121, 122, 123, *124*, 146, 147, 148, 149, 165, 166, 167, 168, 169, 170, *171*, 172, *176*, 178, *179*, 180, 181, 184, 185, *186*, *188*, 189, 191, 192, 193, *194*, 195, 196, 197, 198, *199*, 200, *202*, *204*, *205*, 217, *220*, 222, 224, 225, 228, *229*, 230, 231, 232, 233, *235*, 236, 237, 238, 239, 240, *245*, 247, 249, 250, 252, 253
Peptidases (leucine aminopeptidase)	3.4.-.-	PEP	6, 15, 32, *42*, 80, 95, 98, 106, 107, 108, 112, 113, 114, 138, 169, 172, 192, *203*, *204*, 217, *243*, 247, 249
Peroxidase	1.11.1.7	PER (PX)	92, 93, 94, 139, 141, 180, 181, *188*, *203*, *204*, *243*, 247
Phosphogluconate dehydrogenase (6-phosphogluconate dehydrogenase)	1.1.1.44	PGDH (PGD)	1, 9, 10, *11*, 15, 32, 40, *42*, 44, *45*, 46, 47, *62*, 64, 80, 82, *83*, 89, 95, 98, 106, 107, 112, 113, 114, 120, *171*, 172, *176*, 177, 191, 192, 193, *194*, 195, 196, 197, *199*, *203*, *204*, 217, 218, 219, 237, 238, 239, 247
Phosphoglucomutase	5.4.2.2***	PGM	1, 6, 7, 14, 15, 17, 25, 32, 38, 39, 40, 41, *42*, 44, *45*, 46, 47, 52, 56, 60, 61, *62*, 64, 65, 73, 74, *75*, 76, 77, 79, 80, 81, 82, *83*, 84, 89, 95, 98, 99, 106, 107, 108, 109, 111, 112, 113, 114, 116, 119, 120, 121, 122, 123, *132*, 150, 162, 163, 166, 167, 169, 170, *171*, 172, 184, 191, 192, 193, *194*, 195, 196, 197, 198, *199*, *203*, *204*, 217, 222, 225, 226, 230, 231, 233, 237, 238, 239, 240, *245*, 247, 249, 250, 251
Superoxide dismutase (indophenol oxidase, tetrazolium oxidase)	1.15.1.1	SOD (IPO, TO)	1, 6, 9, 10, *11*, 15, 32, 34, 35, 36, 38, 40, 41, *42*, 44, 46, 47, 61, *62*, 64, 65, 74, 76, 77, 80, 81, 82, *83*, 89, 95, 98, 99, 106, 107, 108, 111, 112, 113, 114, 116, 119, 120, 121, 122, 123, 147, 148, 149, 168, 169, 170, *171*, 172, *176*, 177, 184, 192, 193, *194*, 195, 196, 197, *199*, *203*, *204*, 217, 218, 219, 222, 225, 230, 231, 232, 233, 237, 238, 239, 247
Transferrin		TF	1, 6, 14, 15, 16, 32, 34, *42*, *59*, 61, 95, *97*, 105, *118*, 126, 127, 128, 129, 130, 131, 136, 138, 139, 140, 142, 143, 144, *147*, 153, 154, 155, 156, *157*, 160, 161, 169, 190, *203*, *204*, *223*, *228*, 242, *243*, *245*
Triose-phosphate isomerase	5.3.1.1	TPI	55, 76, 217, 247, 248
Trypsin	3.4.21.4	TRP	206, 207, *208*, 209, *210*, 211, 212, 213, 214, 215, 216

***formerly 2.7.5.1

Table IV

References to enzymes in *S. salar* L so far found to be monomorphic

Enzyme	EC number	Abbreviation	References
Acid phosphatase	3.1.3.2	ACP	15, 32, *42*, 169, *203, 204*, 217, 247
Aconitate hydratase (aconitase)	4.2.1.3	AH (ACO)	*42*, 76, 107, 196, *204*, 217, 247
Adenylate kinase	2.7.4.3	AK	15, 32, *42, 45, 62*, 64, 80, 98, 106, 107, 109, *171*, 172, 192, 193, *194*, 195, 196, 197, *199*, *203, 204*, 217, 247
Alanine aminotransferase (glutamic-pyruvate transaminase)	2.6.1.2	ALAT (GPT)	*42*, 80, 112, 196, *204*, 217, 247
Alkaline phosphatase	3.1.3.1	ALP	15, 113, 138, 169, *203, 204*, 217, *243*
Enolase	4.2.1.11	ENO	6, 217, 247
Fructose-bisphosphatase (fructose-1, 6-diphosphatase)	3.1.3.11	FBP (FDP)	6, *42*, 80, 112, 113, 114, 172, *204*
Fumarate hydratase (fumarase)	4.2.1.2	FH	*42*, 46, 82, *83*, 89, 98, 107, 113, 114, 169, 172, 196, *203*, 217, 247
Fructokinase	2.7.1.4	FK	15, *203, 204*
β-*N*-Acetylgalactosaminidase	3.2.1.53	bGALA	80, 112, 217, 247
Glyceraldehyde-3-phosphate dehydrogenase	1.2.1.12	GAPDH (G3PDH)	6, 32, 40, *42, 45*, *62*, 64, 106, 107, 113, *171*, 172, 192, 193,*194*, 195, 196, 197, *199, 204*, 217, 247
Guanine deaminase	3.5.4.3	GDA	217, 247
N-Acetyl-β-glucosaminidase (hexosaminidase)	3.2.1.30	bGLUA (HEX)	217, 247
Gluocose-6-phosphate dehydrogenase	1.1.1.49	G6PDH (G6PD)	15, 40, *42*, 98, 107,113, 114, 169, 172, 192, 196, *203, 204*, 217
Glutathione reductase	1.6.4.2	GR (GSR)	40, 217, 247
β-Glucuronidase	3.2.1.31	bGUS	40, *42*, *45, 62*, 64, 80, 107, *171*, 172, 192, 193, *194*, 195, 196, 197, *199, 204*
Hydroxyacylglutathione hydrolase	3.1.2.6	HAGH	217
Hexokinase (glucokinase)	2.7.1.1	HK (GK)	15, *42*, 46, 98, 107, 113, 172, 192, 196, *203, 204*
Mannose-6-phosphate isomerase (phosphomannose isomerase, phosphohexo-isomerase)	5.3.1.8	MPI (PMI)	1, 32, *42*, 46, 80, 81, 107, 112, 113, 172, 196, *203, 204*, 217, 247
4-methyl umbelliferyl phosphatase		MUP	80, 112

Enzyme	EC number	Abbreviation	References
Nucleoside-triphosphate pyrophosphatase (inosine triphosphatase)	3.6.1.19	NTP (ITP)	247
Octanol dehydrogenase	1.1.1.73	ODH	32, *42*, 80, 112, *204*
Proline dipeptidase	3.4.13.9****	PEP-D	80, 217, 247
Phosphoglycerate kinase	2.7.2.3	PGK	80, 112, 217, 247
Purine-nucleoside phosphorylase	2.4.2.1	PNP (NP)	217, 247
Succinate dehydrogenase	1.3.99.1	SUCDH	98
Xanthine dehydrogenase	1.1.1.204	XDH	9, 10, *11*, 15, 40, *42*, 44, *45*, 46, 47, *62*, 64, 95, 98, 106, 107, 113, 114, 169, *171*, 172, *176*, 177, 192, 193, *194*, 195, 196, 197, *199*, *204*, 218, 219, 237, 238, 239, 247

****formerly 3.4.3.7

Table V

References to genetic protein variation in *S. salar* L. by subject area

Subject	References
Technique development	119, 131, 184, 206, 209, *210*, 217, 247, 248
Description of variation	6, 7, 14, 15, 16, 17, 31, 32, 33, 35, 41, 43, 44, 47, 53, 60, 80, 81, 82, 86, 91, 95, 96, 98, 103, 111, 112, 113, 120, 126, 127, 128, 129, 131, 133, 134, 135, 136, 137, 138, 139, 141, 144, 147, 150, 151, 154, 156, 158, 159, 160, 165, 169, 170, 180, 181, 184, 185, *186*, 191, 197, 198, 206, 207, *208*, 209, *210*, 213, 216, 217, 226, 236, 239, 241, 242, 243, 246, 247, 248
Inheritance of variation	39, 80, 82, 88, 126, 127, 128, 129, 139, 181, 184, *210*, 213, 236, 248
Biochemistry	86, 91, 145, 151, 206, 207, *208*, *210*, 211, 212, 215, 216
Population differentiation	6, *8*, 9, 10, *12*, 15, 16, 17, 18, *19*, 20, 21, *22*, 23, *24*, 25, 26, 27, 28, 29, 30, 36, 37, 38, 40, *42*, 44, *45*, 47, *50*, *54*, 55, 57, *59*, 61, 64, 65, *66*, *67*, *68*, 69, 71, 73, 74, *75*, 76, 79, 82, *83*, *85*, 89, 92, 93, 94, 96, *97*, 98, 99, 100, *101*, *102*, 104, 105, 107, 108, 109, *110*, 111, 113, 114, 115, 116, *118*, 120, 121, 122, 123, *124*, 126, 127, 128, 129, 130, *132*, 135, 136, 138, 139, 140, 142, 143, 144, 146, 147, 148, 149, 153, 154, 155, 156, *157*, 160, 161, 163, *164*, 166, 167, 168, 169, 170, *171*, 172, *173*, *174*, *175*, *176*, 177, *179*, 180, 183, *188*, 189, 192, 193, *194*, 195, 196, 197, 198, 200, 201, *202*, *203*, *204*, *205*, 218, 219, *220*, 221, 222, *223*, 224, 225, *227*, 228, *229*, 230, 231, 232, 233, *235*, 236, 237, 238, 240, 242, *243*, *244*, *245*, 247, 248, 252, 253
Mixed-stock analysis	10, 15, *19*, 21, *22*, 23, *24*, 27, 36, *42*, 57, *59*, *67*, *68*, 94, 100, *101*, *102*, 105, 108, 109, 120, 121, 122, 123, *124*, *132*, 140, 142, 143, 144, 149, 153, 155, *157*, 160, 161, 166, 167, *173*, *174*, *175*, *194*, 201, *202*, *203*, *204*, 224, 228, *229*, 231, 233, 242, *243*, *244*, *245*
Demography	*2*, *5*, 6, *8*, 10, 13, 14, 26, 28, 37, 38, 40, *45*, 53, 55, 57, 61, 64, 65, 69, 70, 71, 72, 73, 74, *75*, 79, 82, *83*, 86, 87, 88, 89, 90, 94, 98, 99, 100, *102*, 105, 107, 108, 111, 113, 115, 116, 120, 122, 123, 130, 142, 144, 147, 148, 149, 153, 154, 155, 161, 163, 165, 166, 167, 168, 169, *173*, *174*, *175*, *176*, 177, 178, *179*, 180, 183, 184, 185, *186*, 187, *188*, 189, 192, 193, *194*, 195, 197, *199*, 200, 201, *202*, *203*, *204*, 219, *221*, 222, *223*, 225, *227*, 230, 231, 232, 233, *235*, 237, 238, 240, *243*, *244*, *245*, 253
Morphometric/meristic correlates	9, 11, 18, 53, 57, 82, 86, 87, 92, 94, 109, 111, 116, 142, 143, 144, 161, 163, 166, 167, 168, *173*, *204*, 207, *208*, 218, 231
Physiological correlates	58, 64, 87, 163, 165, 178, *183*, 184, *199*, *202*, *203*, *204*, 209, *210*, 211, 212, 213, 214
Environmental correlates	*50*, 53, *83*, *85*, 86, 90, 92, 165, 169, 184, 185, *186*, *188*, *199*, *202*, *204*, 209, *210*, 212, 213, 214, *223*, 232, *235*, *245*, 247, 252, 253
Comparisons with DNA variation	42, *66*, 69, 117, 147, 148, 149, 183, *204*, *234*, 240, 251, 254
Hybridisation	6, 7, *24*, 34, 35, 41, 43, 44, 46, 52, 56, 60, 63, *67*, 70, 77, 78, 80, 81, 84, 91, *97*, 103, 111, 117, *118*, 120, 121, 133, 136, 138, 141, 147, 150, 158, 169, 180, 181, *188*, 190, 191, 195, 197, 226, *234*, 239, 246, 251, 254
Interspecific comparison	1, *3*, *4*, *5*, *24*, *48*, *49*, *50*, 51, 60, 61, *62*, 80, 81, 91, 95, *97*, 112, 131, 125, 134, 137, 138, 145, 150, *152*, *171*, *188*, 206, 236, 248

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